INSTRUCTION MANUAL

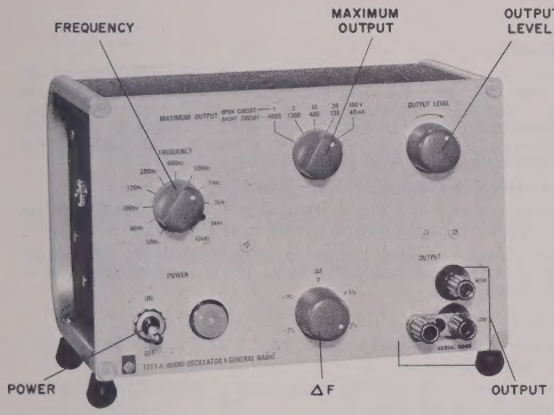
Type 1311-A | AUDIO OSCILLATOR

and

Type 1311-AU | AUDIOMETRIC OSCILLATOR

GENERAL RADIO

CONDENSED OPERATING PROCEDURE



a. Connect the oscillator to a power source with the 3-wire power cord supplied.

b. Connect the load to the OUTPUT terminals.

c. Set the POWER switch to ON.

d. Set the FREQUENCY switch to the center frequency desired.

e. Set the ΔF control to 0 or between 0 and ±2%.

f. Set the MAXIMUM OUTPUT switch to a value in volts or milliamperes that is slightly greater than the amplitude of the voltage or current desired.

g. Rotate the OUTPUT LEVEL control to obtain the desired output level.

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SPECIFICATIONS

FREQUENCY

Range: 1311-A, 50 Hz to 10 kHz. Eleven fixed frequencies, 50, 60, 100, 120, 200, 400, and 500 Hz, 1, 2, 5, and 10 kHz. One other frequency can be added at an unused switch position. 1311-AU, 125 Hz to 8 kHz. Twelve fixed frequencies, 125. 250, 400, 500, and 750 Hz, 1, 1.5, 2, 3, 4, 6, and 8 kHz. Both models, a Δf control provides $\pm 2\%$ continuous adjustment.

Accuracy: $\pm 1\%$ of setting with Δf control at zero.

Stability (typical at 1 kHz): Warmup drift, 0.3%. After warmup: 0.008% short term (10 min), 0.02% long term (12 h).

Synchronization: Frequency can be locked to external signal. Lock range $\pm 3\%$ per volt rms up to 10 V. The Δf control functions as phase adjustment.

OUTPUT

Voltage: Continuously adjustable from 0 to 1, 3, 10, 30, or 100 V open circuit (E_{oc}).

Power: >1.0 W into matched load, >0.5 W into any resistive load between 80 mΩ and 8 kΩ.

Current: Continuously adjustable from 0 to 40, 130, 400, 1300, or 4000 mA, into approx short circuit (I_{sc}).

Impedance: One to three times $\frac{E_{oc}}{I_{sc}}$, depending on output amplitude. Output isolated from ground.

Distortion: $<0.5\%$ with any linear load. Oscillator will drive a short circuit without clipping.

Hum: $<0.01\%$, independent of output setting.

Synchronization: Constant-amplitude (1-V), high-impedance (4.7-kΩ) output to drive counter or oscilloscope.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 22 W.

Terminals: Output, GR 938 Binding Posts and ground terminal with shorting link; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug), rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 7¾ in. (205 x 155 x 200 mm).

Weight: Net, 6 lb (2.8 kg); shipping, 9 lb (4.1 kg).

Catalog Number	Description
1311-9701	**1311-A Audio Oscillator**
	1311-AU Audiometric Oscillator,
1311-9703	for 115-V
1311-9704	for 230-V
1560-9695	**1560-P95 Adaptor Cable**
0480-9838	**480-P308 Rack-Adaptor Set**

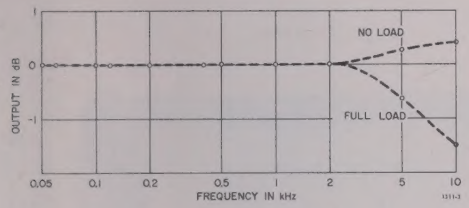
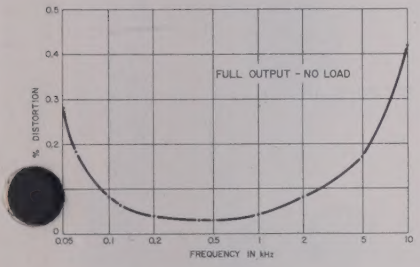
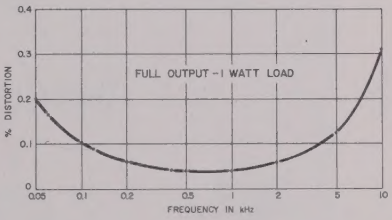


Figure A. Output of Type 1311 as a function of frequency, loaded and unloaded (typical).





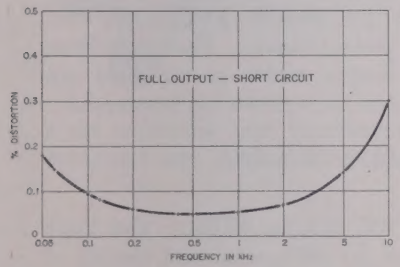


Figure B. Distortion characteristics of Type 1311 as functions of frequency and load (typical).

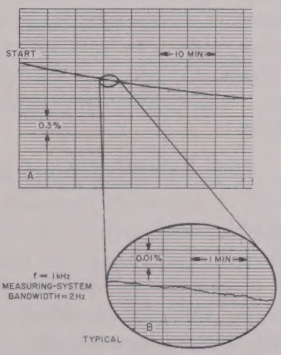


Figure C. Typical output amplitude stability of the oscillator, showing warmup drift (A) and short-term variation (B).

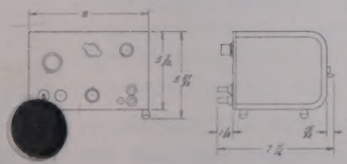


Figure D. Dimensions of the Type 1311.

SECTION 1

INTRODUCTION

1.1 PURPOSE.

1.1.1 GENERAL. The Type 1311 oscillators are complete, compact, and self-contained audio-frequency sources. The Type 1311-A (Figure 1-1) is intended for general laboratory use, and is particularly well suited for use in audio-frequency bridge measurements. Each oscillator produces an essentially pure sinusoidal output, stable in amplitude and frequency, over a wide range of load impedances, at selected frequencies. The Type 1311-A has eleven fixed frequencies and provision for a twelfth, which the user can readily add by installing two precision resistors.

1.1.2 THE TYPE 1311-AU AUDIOMETRIC OSCILLATOR. The Type 1311-AU is primarily intended to be used for calibration and testing of audiometric equipment. It will be especially useful for calibration of audiometric earphones, in conjunction with the Types 1551 and 1565 Sound Level Meters, (or the Type 1564 Sound and Vibration Analyzer), The Type 1560-P5 or -P6 (or the Type 1560-P3 or -P4) Piezoelectric Ceramic Microphone, and the Type 1560-P82 (or -P81) Earphone Coupler. The frequencies available from the Type 1311-AU include all those commonly used as audiometric test frequencies. The difference in output frequencies is the only characteristic in which the Type 1311-AU is unlike the Type 1311-A, and all instructions and descriptions supplied for the Type 1311-A are applicable to the Type 1311-AU unless specifically stated otherwise.

1.2 DESCRIPTION.

1.2.1 GENERAL. The Type 1311 is a transistorized RC Oscillator, which makes extensive use of negative feedback to attain amplitude and frequency stability of a high order, as well as long-term reliability. The

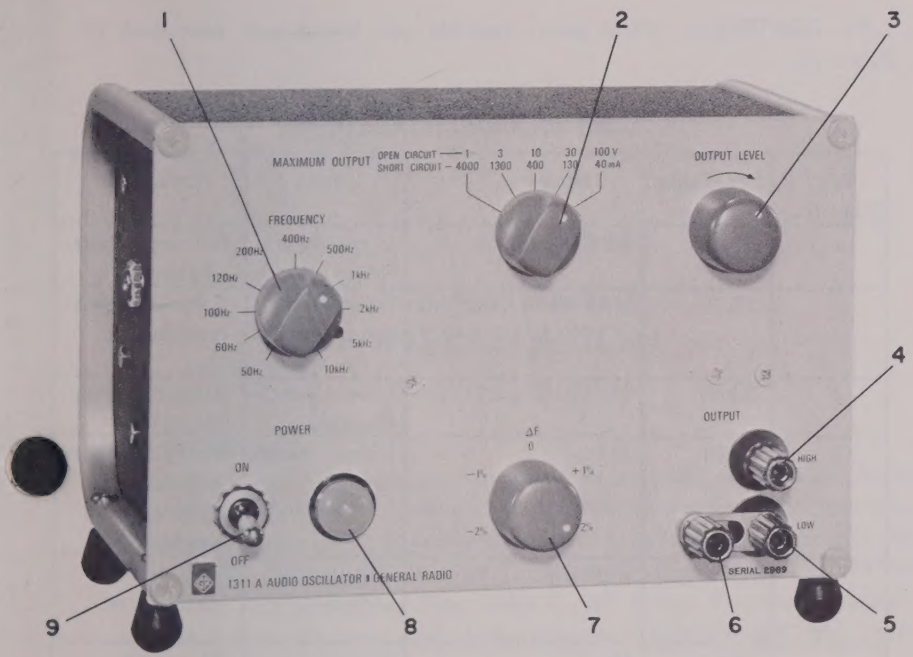


Figure 1-1. Type 1311-A Audio Oscillator.

output system uses a multitap shielded transformer capable of matching impedances from 0.25 to 2500 ohms. It is well isolated from the oscillator circuitry to provide a distortion-free waveform to any impedance, including a short circuit.

The instrument is ac powered and uses a regulated solid-state power-supply circuit to provide stable dc to all stages over a wide range of power demands. Operation at ac inputs of 115 or 230 volts can be achieved by selection of appropriate taps on the input winding of the primary power transformer.

The Type 1311 is designed for bench use but can conveniently and inexpensively be altered for rack mounting by the addition of the General Radio Type 480-P308 Adaptor Plate Set (Catalog No.0480-9838).

1.2.2 CONTROLS. Front panel controls are listed and described in Table 1-1.

TABLE 1-1
CONTROLS AND INDICATORS

Ref (Fig. 1-1)	Ref Desig	Name	Type	Function
1	S101	FREQUENCY	12-position rotary switch	Selects output frequency.
2	S102	MAXIMUM OUTPUT	5-position rotary switch	Selects output transformer tap.
3	R139	OUTPUT LEVEL	Linear potentiometer	Adjusts output level.
7	R138	Δ F	Linear potentiometer	Adjusts output frequency ±2% about nominal.
9	S501	POWER	Toggle switch	Turns instrument on or off.
8	P501	None	Light	Glows when primary power on.

1.2.3 CONNECTORS. Connectors provided on the Type 1311 are listed and described in Table 1-2.

TABLE 1-2
CONNECTORS

Ref (Fig. 1-1)	Ref Desig	Name	Type	Function
4-6	J101 thru J103	OUTPUT	Jack-top binding posts (GR Type 938)	Output terminals and ground.
-	PL501	None	3-prong plug (GR Type 109-A)	Power input terminal.
	J104	None	Telephone	External Sync input

SECTION 2

INSTALLATION

2.1 GENERAL.

The Type 1311-A Audio Oscillator, as supplied, is intended for independent bench use. However, it may be adapted to rack mounting, either independently or in combination with a similarly sized instrument, such as the General Radio Type 1232-A, -AP Tuned Amplifier and Null Detector. This assembly, Type 1240-A, -AP Bridge Oscillator-Detector is convenient for use with audio-frequency bridges and other null-balance devices.

2.2 RACK MOUNTING.

2.2.1 RACK CONVERTING THE TYPE 1311. The Type 1311 Oscillator can be rack-mounted by itself in a standard 19-inch relay rack by means of Relay Rack Adaptor Set, Catalog Number 0480-9838, or with another convertible-bench instrument by means of Relay Rack Adaptor Set, Catalog Number 0480-9836. To attach the adaptor sets, proceed as follows (see Figure 2-1):

a. Remove the rubber feet, if necessary to clear an instrument below.

b. Remove the screws that secure the front panel to the aluminum end frames.

c. Remove the spacers between the front panel and the end frames. If two instruments are to be mounted side by side, join them as follows: (otherwise proceed to step f):

d. On one instrument, install clips with the front-panel screws removed earlier. Remove the cover of this instrument and thread the nylon screw through the hole in the side panel on the same side as the clips.

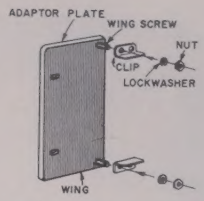


Figure 2-1a. Rack adapting the Type 1311.

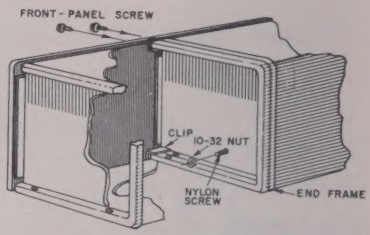


Figure 2-1b. The Type 1240.

e. Secure the two instruments together with front-panel screws through the remaining hole in each clip. Remove the cover of the second instrument, thread the nut onto the nylon screw, and tighten. Note that the instruments can be bench-mounted side by side in this manner. Simply do not remove the two feet from each outside end frame and do not install the adaptor plates..

f. Install two clips on each adaptor plate with the wing screws, lockwashers, and nuts supplied.

g. Attach the adaptor plates to the instrument with the front-panel screws removed earlier.

h. Mount the assembly in the rack with the 10-32 screws supplied.

2.2.2 MOUNTING THE TYPE 1620-A, -AP. The Type 1311 oscillator is an integral part of the Type 1620-A, -AP Capacitance-Measuring Assembly. To assemble a Type 1620-AP, a Type 1232 Detector, Type 1232-P2 Preamplifier, Type 1615 Bridge, Type 4177-1621 System Cabinet and Type 1620-A, a Type 1232 Detector, Type 1615 Bridge, Type 4177-1620 System Cabinet and Type 1620-A hardware set are needed. Proceed as follows:

a. Follow steps a through e in paragraph 2.2.1 for a 1620-A installation, or steps a through 1 of the Type 1240-AP assembly procedure in the Type 1232-P2 Instruction Manual, for a 1620-AP installation.

b. Insert the "ears" of the mounting plates included in the Type 1620-A or -AP hardware set in the spaces between the front panels and the end frames of the Type 1311 and Type 1232.

c. Replace all remaining front panel screws.

d. Mount the Type 1615 in the lower part of the system cabinet using eight panel screws with natural Nylon cup washers.

e. Mount the 1311-1232 combination in the upper portion of the cabinet using four panel screws with Nylon cup washers.

2.3 POWER INPUT.

2.3.1 NORMAL OPERATION. The Type CAP-22 Three-Wire Power Cord (catalog number 4200-9622) supplied should be attached to PL501 on the rear panel and plugged into a standard grounding-type power receptacle providing 105-125 volts at 50 to 400 Hz.

2.3.2 HIGHER VOLTAGE. The instrument may be operated at ac inputs from 210 to 250 volts, provided that minor wiring and fuse changes described in Section 5 have been performed.

2.4 OUTPUT FREQUENCY CHANGE.

To add a 12th audio output frequency (Type 1311 only), or to change any of the existing fixed frequencies, resistor pairs in the Wein-bridge circuit may be installed, or replaced, as described in Section 5.

2.5 ENVIRONMENTAL CONSIDERATIONS.

2.5.1 TEMPERATURE. The Type 1311 will operate within specifications over an ambient temperature range of 0 to 50 C. It is not affected by humidity.

2.5.2 EXTERNAL FIELDS. Since the Type 1311 is often mounted with the sensitive Type 1232-A Null Detector, stray magnetic and electrostatic fields should be kept to a minimum by suitable shielding, and orientation of signal leads. A wire loop is included (internally) near the output terminals to cancel the magnetic field resulting from the ¾-inch spacing of the output terminals, and will prevent magnetic pickup in the adjacent null detector, even at high current levels, if a General Radio Type 274-MB Shielded Output Cable is used. Alternatively, the Type 1311 can be mounted at the right-hand side of the Type 1232-A, to place the output circuit as far as possible from the detector input terminals.

SECTION 3

OPERATING PROCEDURE

3.1 PREPARATION FOR USE.

3.1.1 POWER CONNECTIONS. Connect the Type 1311 to a suitable source of power as indicated on the plate above the power receptacle on the rear panel. A three-wire power cord (Type CAP-22) is supplied.

3.1.2 GROUNDING. The instrument should normally be operated with the chassis grounded through the three-wire power cord. If the cord is not used, make the ground connection at J103 (6, Figure 1-1) on the front panel, if required.

3.1.3 OUTPUT CONNECTION. Take the oscillator output from the jack-top binding post pair J101 - J102 (4 and 5, Figure 1-1). J101 is always used above ground, but J102 may be grounded or ungrounded, depending on the requirements of the test setup in use. A captive shorting-link affixed to J103 may be attached to J102, if it is desired to work one side of the output against ground. However, if ground loops pose a problem, disconnect the shorting link from J102 to achieve a completely isolated "floating" output.

3.1.4 OUTPUT-SHIELDING ACCESSORIES. In applications in which stray pickup is apt to be troublesome, use of a shielded patch cord is suggested. The General Radio Type 274-NL Patch Cord, a polarized 3-foot shielded cable with a shielded double plug at each end, is available for this purpose.

3.2 OPERATING PROCEDURE.

3.2.1 TURN-ON. Place the POWER switch (9, Figure 1-1) in up position; the lamp immediately to the right should glow.

NOTE

No extensive warm-up time is required; a few seconds is sufficient.

3.2.2 FREQUENCY SELECTION. Set the FREQUENCY switch (1, Figure 1-1) to the desired frequency. Use the ΔF control (7, Figure 1-1) to adjust the selected frequency over a range of approximately ±2% of nominal. The frequency of the output waveform is within ±1% of the panel

engraving, with the ΔF control set at 0. For greater precision monitor the output with a counter, such as the General Radio Type 1191 counter.

3.2.3 POWER SELECTION. Set the MAXIMUM OUTPUT switch (2, Figure 1-1) to a value in volts or milliamperes (as screened on the front panel) that is slightly greater than the amplitude of the voltage or current desired. Then, rotate the OUTPUT control (3, Figure 1-1) to make the fine adjustment. The OUTPUT control sets the output at zero in its fully counterclockwise position, and rotated to its fully clockwise position provides a continuous linear increase up to the value of the MAXIMUM OUTPUT control setting.

The maximum power output is approximately 1.1 watt, so that bridges with 1-watt ratio arms, such as most General Radio bridges, can not be damaged by overload. At least 0.58 watt of signal power can be supplied to any load between 80 milliohms and 8 kilohms, with the appropriate setting of the output switch. See Figure 3-1 for a plot of these values.

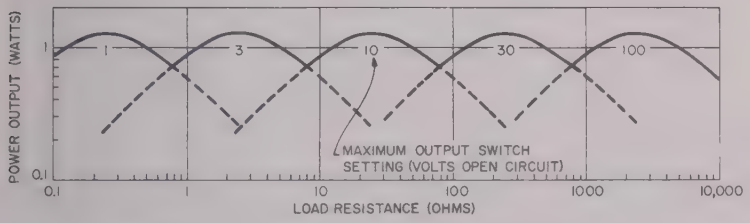


Figure 3-1. Typical power output as a function of load resistance.

3.2.4 IMPEDANCE MATCHING. Any setting of the output controls can be used with any load impedance without overloading the oscillator circuits. Even with a short circuit across the output terminals, the oscillator will still supply a sinusoidal current of the value indicated by the MAXIMUM OUTPUT control. This feature is particularly convenient when the oscillator is used as a source for ac bridge measurements, since it means that the output controls can be set to any position, and the waveform will not be distorted by mismatching.

The output winding is shielded from the oscillator circuits and may be used ungrounded, or grounded at a remote point. The latter procedure

is recommended when the oscillator is used in bridge measurements, to eliminate circulating ground currents, which can cause errors.

The nominal source resistance is a function of the transformer tap selected by the MAXIMUM OUTPUT control setting and the position of the OUTPUT control. Figure 3-2 shows the relationship.

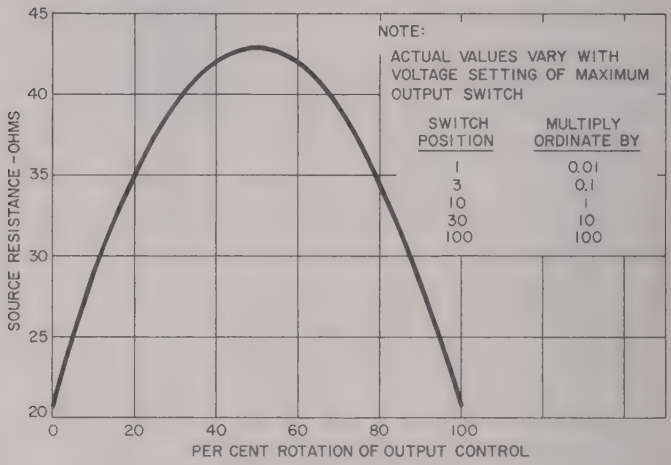


Figure 3-2. Source resistance as a function of output control settings.

3.2.5 FREQUENCY SYNCHRONIZATION. A telephone jack (J104) on the left side wall of the cabinet is provided to permit injection of an external standard frequency to control the output frequency of the Type 1311. This is particularly useful to drive the Type 1615-A Capacitance Bridge when making precise measurements of frequency-sensitive parameters such as dissipation factor. A 1-volt signal will result in a locking range of approximately ±3%. For larger synchronizing signals, a resistor should be added in series with the signal lead. Use the following equation to calculate the value of the resistor required.

$$R \text{ (in kilohms)} \approx 5 \text{ (Sync Volts} - 1)$$

The dc voltage on the reference signal should not exceed +50 volts. For additional information on synchronization, write for Instrument Note 109.

The 1-watt amplifier and matching transformer of the 1311-A can be driven by any of the 1300 oscillator series between 50 and 10,000 Hz. Set the 1311-A's FREQUENCY switch to the blank position and plug the external oscillator into the sync jack.

SECTION 4

PRINCIPLES OF OPERATION

4.1 GENERAL.

The Type 1311-A and -AU Audio Oscillators use a Wien-type network and a closed-loop, transistor-amplifier circuit to obtain a stable yet inexpensive signal source which will satisfy many oscillator requirements in the audio-frequency spectrum. See Figure 4-1 for a simplified diagram and Figure 5-2 for the complete schematic.

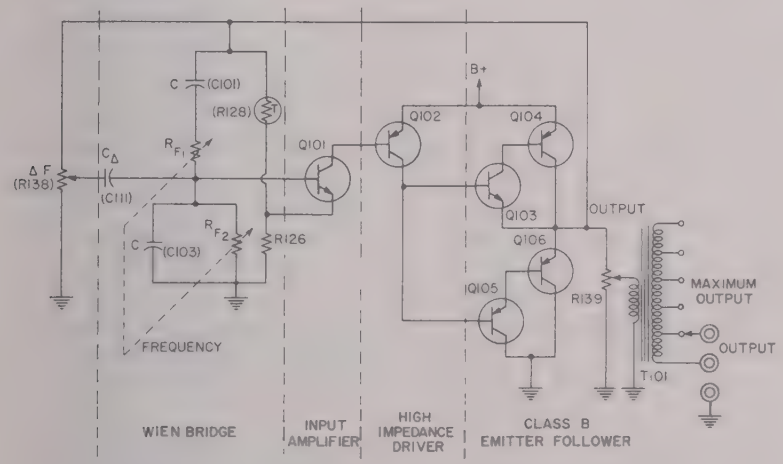


Figure 4-1. Simplified schematic diagram.

4.2 CIRCUIT DESCRIPTION.

4.2.1 FREQUENCY-DETERMINING NETWORK. The Wien-bridge circuit can be thought of as consisting of two parts: a frequency-determining network (C101, C103 and paired resistors R_{F1}.R_{F2}), which provides positive feedback to sustain oscillation, and a resistive divider (R128 and R126) which provides negative feedback to stabilize amplitude.*

* For a detailed dicussion of this design feature, see Fulks, R. G., "Novel Feedback Loop Stabilizes Audio Oscillator," ELECTRONICS, Vol. 36 No. 5 February, 1963. Available as General Radio reprint A-107.

The frequency-determining network has a transfer function:

$$\frac{e_{OUT}}{e_{IN}} = \frac{RCs}{1 + 3RCs + R^2C^2s^2}$$

where $s = j2\pi f$

$R = R_{F1} = R_{F2}$

$C = C101 = C103$

At some oscillator frequency, f_o, this function equals +1/3. The frequency is determined by any of 11 pairs of precision metal-film resistors, R_{F1}, R_{F2}, selected by the FREQUENCY switch. With this circuit, frequency can be adjusted over a 200-to-1 range simply by changes in resistors. The frequency vernier adjustment, ΔF, is potentiometer R138, which controls the signal voltage on C_Δ (C111), one of the capacitors in the network.

The resistive divider is used to set the gain of the associated amplifier chain to +3. The net loop gain is then +1 and the circuit oscillates at the frequency f_o.

A small bead thermistor, R128, automatically adjusts its resistance to the value needed to maintain oscillations. Its time constant is short enough to provide rapid correction for amplitude variations, yet long enough to cause little distortion at the lower frequencies. It operates at a high temperature, in an evacuated bulb, to minimize the effects of ambient temperature. This thermistor, used with the high-stability, low-noise amplifier described below, results in an oscillator with amplitude (modulation) noise typically less than 0.01% rms.

4.2.2 AMPLIFIER. The amplifier uses six transistors in a single, direct-coupled feedback loop. The input circuit is chosen for low-noise performance. Transistor Q102 provides a high-impedance drive for the class-B output stage, and achieves a minimum of crossover distortion, yet does not require complicated, temperature-sensitive biasing networks. Negative feedback is used to obtain a transfer characteristic which is substantially independent of transistor characteristics, resulting in excellent stability, low distortion, and long-term reliability. Components R132, C107, and C108 comprise a phase-compensation network used to maintain high-frequency stability in view of the large amount of negative feedback involved.

The input impedance of the amplifier is approximately 10 megohms. The output impedance is approximately 0.005 ohm, so that changes in load have very little effect on the oscillator.

4.2.3 OUTPUT TRANSFORMER. The winding resistance of the output transformer, T101, isolates the oscillator from the load and ensures that the output waveform will not be clipped under any load condition. The output winding is tapped to provide five switch-selectable, output-voltage ranges to match a wide variety of load requirements. The output winding is doubly shielded from the oscillator circuits for isolation, when the output is used off ground (floating). A simplified schematic diagram of the output circuit is shown in Figure 4-2.

The second shield is used to minimize possible current flow through the distributed capacitance, C_{FL} ($\approx$500pf), thence through an external circuit ground. The resulting floating potential, E_{FL}, of the output winding is less than 0.25 volt.

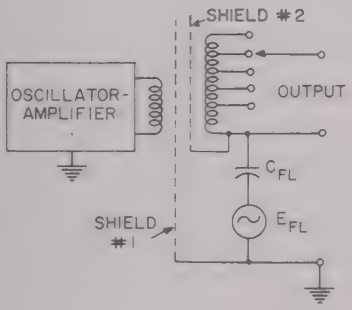


Figure 4-2. Simplified schematic diagram of output circuit.

4.2.4 POWER SUPPLY. Power transformer, T501, is used to apply 25.5 v ac to a silicon-diode bridge-rectifier and filter circuit. The filtered dc output passes through a simple regulator circuit, made up of Q501, Q502, and CR505, a zener diode. The supply provides a low-impedance, ripple-free, 20-v dc source to power the oscillator circuitry. The hum level of the oscillator output is typically 90 db below rated output signal value.

SECTION 5

SERVICE AND MAINTENANCE

5.1 WARRANTY.

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, for tubes or batteries that have given normal service.

5.2 SERVICE.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble, and of steps taken to remedy it. Be sure to mention the type and serial numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.3 MINIMUM PERFORMANCE STANDARDS.

The Type 1311 in normal operation should perform within the standards described in Table 5-1. Table 5-2 lists the test equipment required to check minimum performance. If the instrument does not meet minimum performance standards, refer to paragraph 5.6 for trouble analysis procedures.

5.4 INPUT POWER.

The input power at 115/230 volts 60 Hz normally should not exceed 7 watts no load and 22 watts with the terminals short-circuited and the OUTPUT control fully clockwise.

TABLE 5-1
MINIMUM PERFORMANCE STANDARDS FOR TYPE 1311-A, -AU

TEST	FREQUENCY SWITCH POSITION	MAXIMUM OUTPUT SWITCH POSITION	OUTPUT CONTROL POSITION	ΔF POSITION	LOAD	NORMAL INDICATION	IF INDICATION ABNORMAL
Frequency Accuracy	All	10 v	cw stop	0	None	Using frequency counter or meter, check that the frequency is within ±1% of nominal value.	Refer to para 5.6.
Δf Control	1 kHz	10 v	cw stop	-2%, 0, +2%	None	Using frequency counter or meter, check that frequency change is approximately plus and minus 2%.	Refer to para 5.6.
Output Voltage	1 kHz	All	cw stop	0	None	Using VTVM, check that output voltage is greater than that indicated by MAXIMUM OUTPUT Control.	Adjust by means of R129 (para 5.8.1).
Output Voltage	All	10 v	cw stop	0	None	Using VTVM, check that output voltage is greater than 10 volts.	Adjust by means of R129 (para 5.8.1).
OUTPUT Control	1 kHz	10 v		0	None	Using VTVM, check that output voltage can be adjusted by OUTPUT Control from 0 to 10 v.	Refer to para 5.6.
Output Power	1 kHz	10 v	cw stop	0	Power Output Meter	Using Power Output Meter, check that output power is greater than 1.0 watt into some impedance near 25 Ω.	Adjust by means of R129 (para 5.8.1).
Output Distortion	50 Hz* 1 kHz 10 kHz	10 v	cw stop	0	(None) (25 Ω) (1 Ω)	Using Distortion Meter, check that distortion is less than 0.5%.	Refer to para 5.6.
Synchronization	1 kHz	10 v	cw stop	0	None	Apply 1-v, 1-kHz signal to J104. With oscilloscope at OUTPUT, vary ext.-oscillator freq. Type 1311 should remain locked over a 5% range (approx)	Refer to para 5.6.

**125Hz for the Type 1311-AU.*

TABLE 5-2
TEST EQUIPMENT REQUIRED

Description	Recommended GR Type Numbers*
Frequency Counter	1191
Vacuum Tube Voltmeter	1806-A
Distortion and Noise Meter or Wave Analyzer	1932-A, or 1900-A
Output-Power Meter	1840-A
Variable-Frequency Audio Oscillator	1310-A
Oscilloscope	Laboratory quality, min bandwidth 1 kHz, min vert sensitivity 5 v/cm
Multimeter	Sensitivity 20,000 ohms/v

*Or equivalent

5.5 REMOVAL OF COVER.

To remove the cover, loosen the two captive thumb screws on the rear of the case and pull straight back.

5.6 TROUBLE ANALYSIS.

Perform the following procedures to isolate defects causing instrument malfunction as indicated by paragraphs 5.3 and 5.4. See Figures 5-1 through 5-5 for circuit function and part location.

a. Disconnect primary power and remove cover.

b. Check fuses F501 and F502; replace if defective.

c. Visually check detail parts inside instrument for obvious defects, such as broken leads or charred surfaces. Repair or replace, as necessary.

d. Reapply primary power and, with multimeter, check for 25 v ac across anchor terminals AT501 and AT502.

CAUTION

Semiconductor elements can be damaged by transients resulting from the insertion of instrument probes. Always turn off the power before connecting any test equipment to other than the output terminals. Restore power when connection is made.

e. Switch multimeter to dc scale and check voltages as indicated on Figure 5-2. For accessibility of test points on etched-circuit board, see Figure 5-5.

NOTE

Complete circuit is enclosed in a single dc feedback loop, so that failure of one component will probably cause all voltages to differ considerably from the values shown.

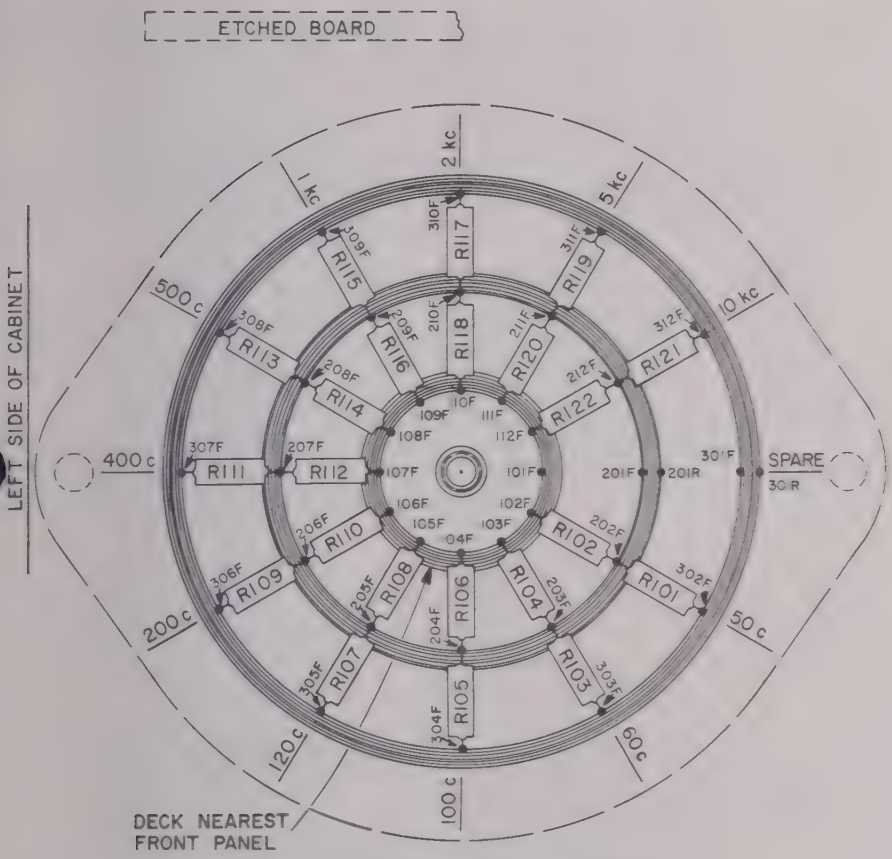


Figure 5-1a. Wiring diagram for FREQUENCY switch S101 on the Type 1311-A.

5.7 REMOVAL AND REPLACEMENT.

5.7.1 GENERAL. Faulty parts should be removed and replaced by units meeting the description given in the Parts List at the end of this section.

5.7.2 SEMICONDUCTORS. Since the expected life of the semiconductor elements in the Type 1311 is comparable to that of other components, they are soldered into the circuit boards. As a general rule, it is much safer to determine the faulty semiconductors from over-all circuit test, rather than to remove them individually for testing.

CAUTION

Transistors are easily damaged by excessive heat; exercise care when unsoldering them.

5.7.3 PILOT LIGHT. The pilot light (P501) is operated well below its rated voltage. If a change is required, unscrew the red cap from the front of the panel and replace the light with a Mazda # 44.

5.8 INTERNAL ADJUSTMENTS. (See Figures 5-2 through 5-5.)

5.8.1 OSCILLATOR LEVEL. R129, a secondary control used to adjust oscillator power level, is a screw-driver-adjustable potentiometer mounted on the underside of the etched circuit at its inside edge. With the dust cover removed, it is accessible from the bottom of the instrument.

R129 should be set so that the no-load output voltage, as indicated by a VTVM across the OUTPUT terminals, is approximately 5% higher than the value indicated by the MAXIMUM OUTPUT switch, when the OUTPUT control is turned fully clockwise.

5.8.2 OSCILLATOR FREQUENCY. Any frequency between 50 hertz and 10 kHz can be added to those provided on the Type 1311-A, by the installation of two precision resistors, R_F, whose values can be determined from the following relation:

$$R_F = 1.61 \times 10^3 \frac{(1\ \text{kHz})}{(f_{\text{kHz}})}$$

To utilize the twelfth position of the FREQUENCY selector switch, first calculate the value of the resistors required. For example, if a 600-Hz output is wanted, then

$$R_F = 1.61 \times 10^3 \frac{(1000)}{(0.6)} = 2.66 \text{ kilohms.}$$

The resistors must be mounted on the FREQUENCY switch (S101). An unused position (between the 50-Hz and 10-kHz positions) is provided for this purpose. Before installing the resistors on S101, remove the jumper between contacts 101F and 201F. The contacts 101F, 201F, and 301F may be reached from the bottom of the instrument. See Figure 5-1a for switch details. All twelve switch positions are used on the Type 1311-AU. These are shown in Figure 5-1b.

5.9 AC POWER CONVERSION.

5.9.1 GENERAL. The Type 1311 is available from the factory wired either for use with inputs of 105 to 125 or 210 to 250, 50 to 400 Hz. However, if the user wishes to convert the instrument from one power option

to the other, it is necessary merely to change wiring to the power-transformer input winding from power switch S501 and replace fuses.

WARNING

Pull the power cord from the receptacle before performing the following procedures.

5.9.2 TRANSFORMER WIRING. Remove the dust cover and place the instrument upside down on the bench. The input transformer (T501) is mounted on the side wall.

For 115-volt operation, transformer leads 1 and 3 should connect to lug 5 on S501 and leads 2 and 4 to lug 6 on S501. For 230-volt operation, lead 1 connects to lug 5, lead 4 to lug 6, and leads 2 and 3 are joined at anchor terminal AT506.

5.9.3 FUSES. Two fuses (F501 and F502), mounted on the inside of the vertical panel at the top rear, protect the instrument from electrical overload. They are accessible from the bottom, also. For 115 v, use 0.25-amp fuses; and for 230 v, use 0.125-amp fuses.

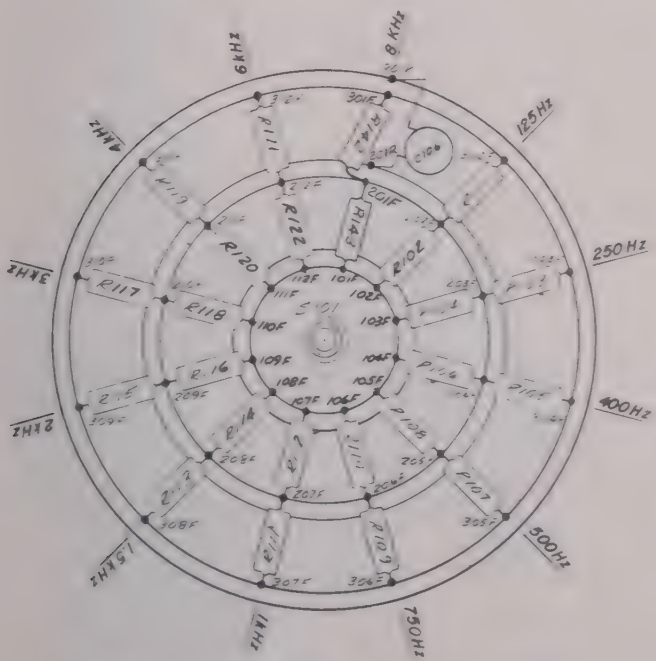


Figure 5-1b. Wiring diagram for FREQUENCY switch S101 on the Type 1311-AU.

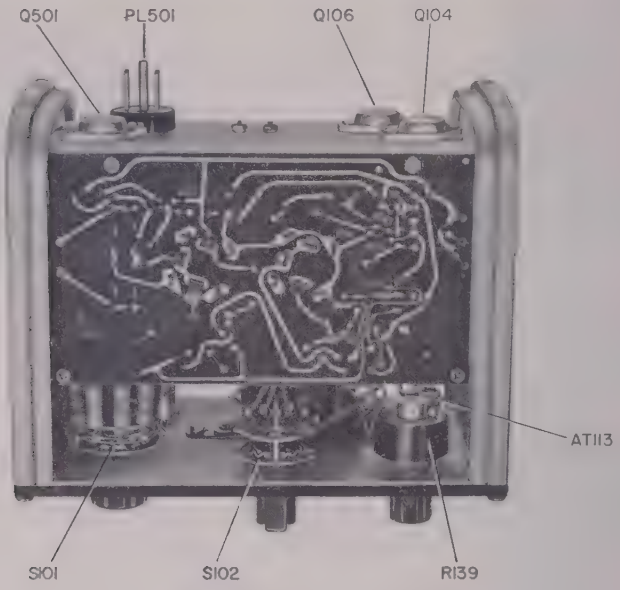


Figure 5-3. Top rear interior view.

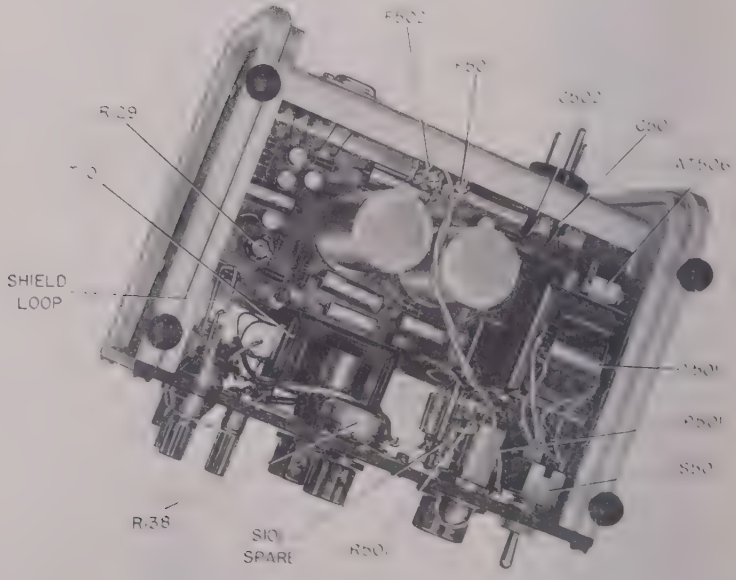


Figure 5-4. Bottom rear interior view.

5.10 KNOB REMOVAL AND INSTALLATION.

To remove a knob, proceed as follows:

a. Grasp knob firmly with fingers, close into panel and pull straight away from the panel.

b. Observe position of bushing setscrew with respect to any panel markings, release setscrew and pull bushing off shaft.

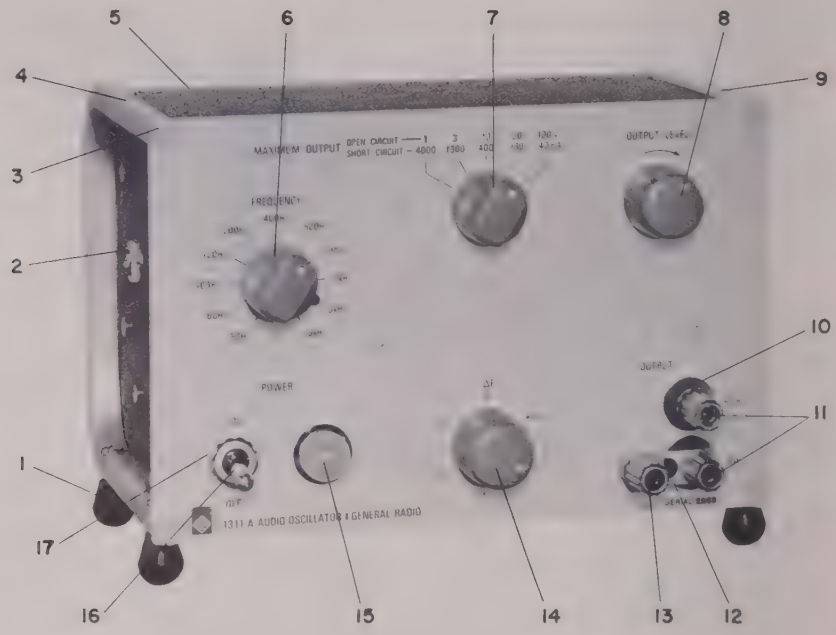
To install a knob, proceed as follows:

a. Mount bushing using paper as a shim.

b. Orient setscrew to markings noted when it was removed. Tighten setscrew. The shaft must not protrude through bushing.

c. Place knob on bushing with retention spring opposite setscrew.

d. Push knob in until it bottoms and pull it slightly to check spring retention. If knob-retention spring comes loose, reinstall it in interior notch with small slit in outer wall.



MECHANICAL PARTS LIST

Figure Reference	Description	GR Part Number	Fed Mfg. Code	Mfg. Part No.	Fed. Stk. No.
1	FOOT, rubber, soft, No. 10-32 top, 4 required	5260-0700	24655	5260-0700	5340-738-6329
2	NUT, dress, 3/8-32	5800-0805	24655	5800-0805	
3	SCREW, Phillip-head with washer No. 10-32, 1/2-in., 4 required	7098-0160	24655	7098-0160	
	WASHER (between panel and end frame) metal, No. 10, 4 required	8100-1517	24655	8100-1517	
4	END FRAME, left	5310-3065	24655	5310-3065	
5	DUST COVER Assembly	4429-1500	24655	4429-1500	
6, 7	KNOB (includes tension spring), bar, white dot and line	5500-5321	24655	5500-5321	
	BUSHING (includes setscrew), metal	4143-3121	24655	4143-3121	
	TENSION SPRING	5220-5402	24655	5220-5402	
8, 14	KNOB (includes tension spring), skirted, white dot and line	5520-5321	24655	5520-5321	
	BUSHING (includes setscrew), metal	4143-3121	24655	4143-3121	
	TENSION SPRING	5220-5402	24655	5220-5402	
	WASHER, metal, No. 1/4	8100-0400	24655	8100-0400	5340-984-1081
9	END FRAME, right	5310-3064	24655	5310-3064	
10	INSULATOR, gray, 4 required	0938-7130	24655	0938-7130	
11	BINDING POST ASM.	0938-3000	24655	0938-3000	
12	SHORTING LINK, metal	5080-4800	24655	5080-4800	5940-927-7452
13	BINDING POST ASM.	0938-3022	24655	0938-3022	
15	PILOT LAMP CAP, red	5620-0800	72619	95-935 Cap (Unfluted)	
16	SWITCH, toggle, double-pole single-throw	7910-1300	04009	83053-SA	5930-909-3510
17	NUT, dress, 15/32-32	5800-0800	24655	5800-0800	5310-344-3634

PARTS LIST

REF NO	DESCRIPTION	PART NO	FED. MFG. CODE	MFG. PART NO.	FED. STK. NO.
CAPACITORS					
C101	Plastic, 0.1μF ±1% 100 V	4860-8249	84411	GR-8 0.1 μF ±1%	
C102	Electrolytic, 100μF 15 V	4450-2800	56289	D17872	5910-034-5368
C103	Plastic, 0.1μF ±1% 100 V	4860-8249	84411	GR-8, 0.1 μF ±1%	
C104	Ceramic, 0.0015μF ±10% 500 V	4406-2158	72982	811, 0.0015 μF ±10%	
C105A	Electrolytic, 1500μF 15 V	4450-0700	90201	203828510C10X2	5910-976-9415
C105B,C	Electrolytic, 1500μF 25 V	4450-0700	90201	203828510C10X2	5910-976-9415
C106	Ceramic, 0.0022μF ±10%	4406-2228	72982	811, 0.0022 μF ±10%	
C107	Ceramic, 680pF ±20% 500 V	4404-1689	72982	831, 680 pF ±20%	
C108	Plastic, 0.033μF ±10% 100 V	4860-7865	84411	663UW, 0.033 μF ±10%	
C109	Electrolytic, 100μF 15 V	4450-2800	56289	D17872	5910-034-5368
C110	Electrolytic, 100μF 15 V	4450-2800	56289	D17872	5910-034-5368
C111	Mica, 3300pF ±10%	4570-1333	14655	5A, 3300 pF ±10%	
C112	Electrolytic, 5μF +100-10% 50 V	4450-3900	37942	2040595S9C10X3	5910-448-5527
C501	Ceramic, 0.0033μF ±20% 500 V	4406-2339	72982	811, 0.0033 μF ±20%	
C502	Ceramic, 0.0033μF ±20% 500 V	4406-2339	72982	811, 0.0033 μF ±20%	
C503A	450μF 100 V				
C503B	Electrolytic, 225μF 100 V	4450-4000	74861	1B85 ORT	5910-448-5397
C503C	225μF 100 V				
RESISTORS					
R101	Film, 32.1 kΩ ±1% 1/2 W	6450-2321	75042	CEC-TO, 32.1 kΩ ±1%	
R102	Film, 32.1 kΩ ±1% 1/2 W	6450-2321	75042	CEC-TO, 32.1 kΩ ±1%	
R103	Film, 26.8 kΩ ±1% 1/2 W	6450-2268	75042	CEC-TO, 26.8 kΩ ±1%	
R104	Film, 26.8 kΩ ±1% 1/2 W	6450-2268	75042	CEC-TO, 26.8 kΩ ±1%	
R105	Film, 16.1 kΩ ±1% 1/2 W	6450-2161	75042	CEC-TO, 16.1 kΩ ±1%	
R106	Film, 16.1 kΩ ±1% 1/2 W	6450-2161	75042	CEC-TO, 16.1 kΩ ±1%	
R107	Film, 13.4 kΩ ±1% 1/2 W	6450-2134	75042	CEC-TO, 13.4 kΩ ±1%	
R108	Film, 13.4 kΩ ±1% 1/2 W	6450-2134	75042	CEC-TO, 13.4 kΩ ±1%	
R109	Film, 8.03 kΩ ±1% 1/2 W	6450-1803	75042	CEC-TO, 8.03 kΩ ±1%	
R110	Film, 8.03 kΩ ±1% 1/2 W	6450-1803	75042	CEC-TO, 8.03 kΩ ±1%	
R111	Film, 4.01 kΩ ±1% 1/2 W	6450-1401	75042	CEC-TO, 4.01 kΩ ±1%	
R112	Film, 4.01 kΩ ±1% 1/2 W	6450-1401	75042	CEC-TO, 4.01 kΩ ±1%	
R113	Film, 3.21 kΩ ±1% 1/2 W	6450-1321	75042	CEC-TO, 3.21 kΩ ±1%	
R114	Film, 3.21 kΩ ±1% 1/2 W	6450-1321	75042	CEC-TO, 3.21 kΩ ±1%	
R115	Film, 1.61 kΩ ±1% 1/2 W	6450-1161	75042	CEC-TO, 1.61 kΩ ±1%	
R116	Film, 1.61 kΩ ±1% 1/2 W	6450-1161	75042	CEC-TO, 1.61 kΩ ±1%	
R117	Film, 803 Ω ±1% 1/2 W	6450-0803	75042	CEC-TO, 803 Ω ±1%	
R118	Film, 803 Ω ±1% 1/2 W	6450-0803	75042	CEC-TO, 803 Ω ±1%	
R119	Film, 321 Ω ±1% 1/2 W	6450-0321	75042	CEC-TO, 321 Ω ±1%	
R120	Film, 321 Ω ±1% 1/2 W	6450-0321	75042	CEC-TO, 321 Ω ±1%	
R121	Film, 161 Ω ±1% 1/2 W	6450-0161	75042	CEC-TO, 161 Ω ±1%	
R122	Film, 161 Ω ±1% 1/2 W	6450-0161	75042	CEC-TO, 161 Ω ±1%	
R101	Film, 12.9 kΩ ±1% 1/2 W	6450-2129	75042	CEC-TO, 12.9 kΩ ±1%	
R102	Film, 12.9 kΩ ±1% 1/2 W	6450-2129	75042	CEC-TO, 12.9 kΩ ±1%	
R103	Film, 6.49 kΩ ±1% 1/2 W	6450-1649	75042	CEC-TO, 6.49 kΩ ±1%	
R104	Film, 6.49 kΩ ±1% 1/2 W	6450-1649	75042	CEC-TO, 6.49 kΩ ±1%	
R105	Film, 4.01 kΩ ±1% 1/2 W	6450-1401	75042	CEC-TO, 4.01 kΩ ±1%	
R106	Film, 4.01 kΩ ±1% 1/2 W	6450-1401	75042	CEC-TO, 4.01 kΩ ±1%	
R107	Film, 3.21 kΩ ±1% 1/2 W	6450-1321	75042	CEC-TO, 3.21 kΩ ±1%	
R108	Film, 3.21 kΩ ±1% 1/2 W	6450-1321	75042	CEC-TO, 3.21 kΩ ±1%	
R109	Film, 2.15 kΩ ±1% 1/2 W	6450-1215	75042	CEC-TO, 2.15 kΩ ±1%	5905-542-8407
R110	Film, 2.15 kΩ ±1% 1/2 W	6450-1215	75042	CEC-TO, 2.15 kΩ ±1%	5905-542-8407
R111	Film, 1.61 kΩ ±1% 1/2 W	6450-1161	75042	CEC-TO, 1.61 kΩ ±1%	
R112	Film, 1.61 kΩ ±1% 1/2 W	6450-1161	75042	CEC-TO, 1.61 kΩ ±1%	
R113	Film, 1.07 kΩ ±1% 1/2 W	6450-1107	75042	CEC-TO, 1.07 kΩ ±1%	
R114	Film, 1.07 kΩ ±1% 1/2 W	6450-1107	75042	CEC-TO, 1.07 kΩ ±1%	
R115	Film, 803 Ω ±1% 1/2 W	6450-0803	75042	CEC-TO, 803 Ω ±1%	
R116	Film, 803 Ω ±1% 1/2 W	6450-0803	75042	CEC-TO, 803 Ω ±1%	
R117	Film, 536 Ω ±1% 1/2 W	6450-0536	75042	CEC-TO, 536 Ω ±1%	
R118	Film, 536 Ω ±1% 1/2 W	6450-0536	75042	CEC-TO, 536 Ω ±1%	
R119	Film, 402 Ω ±1% 1/2 W	6450-0402	75042	CEC-TO, 402 Ω ±1%	

PARTS LIST - CONTINUED

REF NO	DESCRIPTION	PART NO	FED. MFG. CODE	MFG. PART NO.	FED. STK. NO.
R120	Film, 402 Ω ±1% 1/2 W	6450-0402	75042	CEC-TO, 402 Ω ±1%	
R121	Film, 267 Ω ±1% 1/2 W	6450-0267	75042	CEC-TO, 267 Ω ±1%	
**R122	Film, 267 Ω ±1% 1/2 W	6450-0267	75042	CEC-TO, 267 Ω ±1%	
R142	Film, 200 Ω ±1% 1/2 W	6450-0200	75042	CEC-TO, 200 Ω ±1%	5905-542-9383
R143	Film, 200 Ω ±1% 1/2 W	6450-0200	75042	CEC-TO, 200 Ω ±1%	5905-542-9383
R123	Composition, 11 kΩ ±5% 1/2 W	6100-3115	01121	RC20GF113J	5905-279-2667
R124	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R125	Composition, 33 kΩ ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R126	Composition, 220 Ω ±5% 1/2 W	6100-1225	01121	RC20GF221J	5905-279-3513
R127	Composition, 150 Ω ±5% 1/2 W	6100-1155	01121	RC20GF151J	5905-299-1541
R128	Thermistor, 30 kΩ ±25%	6740-1402	02606	GB43V1	
R129	Potentiometer, carbon, 250 Ω ±20%	6040-0200	01121	FWC, 250 Ω ±20%	5905-072-7723
R130	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R131	Composition, 6.8 kΩ ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R132	Composition, 10 Ω ±5% 1/2 W	6100-0105	01121	RC20GF100J	5905-190-8883
R133	Composition, 680 Ω ±5% 1/2 W	6100-1685	01121	RC20GF681J	5905-195-6791
R134	Composition, 24 Ω ±5% 1/2 W	6100-0245	01121	RC20GF240J	5905-279-1750
R135	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R136	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
R137	Composition, 24 Ω ±5% 1/2 W	6100-0245	01121	RC20GF240J	5905-279-1750
R138	Potentiometer, Carbon, 250 Ω ±10%	6000-0100	01121	JU, 250 Ω ±10%	
R139	Potentiometer, Wire-wound, 20 Ω ±5%	0971-3905	24655	0971-3905	
R140	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R141	Composition, 150 Ω ±5% 1/2 W	6100-1155	01121	RC20GF151J	5905-299-1541
R501	Wire-wound, 6.8 Ω ±10% 2 W	6760-9689	75042	BWH, 6.8 Ω ±10%	5905-930-2613
R502	Composition, 47 Ω ±5% 1/2 W	6100-0475	01121	RC20GF470J	5905-252-4018
R503	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
R504	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF222J	5905-279-1876
MISCELLANEOUS					
CR501 thru CR504	DIODE, 1N3253	6081-1001	79089	IN3253	5961-814-4251
CR505	DIODE, 1N969B, 22-V ±5% Zener	6083-1058	04713	IN969B	
F501	FUSE, Slow-blow, 0.15 Amp (230V)	5330-0500	71400	MDL, 0.15 Amp.	
F502	FUSE, Slow-blow, 0.15 Amp (230V)	5330-0500	71400	MDL, 0.15 Amp.	
F501	FUSE, Slow-blow, 0.30 Amp (115V)	5330-0800	71400	MDL, .3 Amp.	5920-235-8362
F502	FUSE, Slow-blow, 0.30 Amp (115V)	5330-0800	71400	MDL, .3 Amp.	5920-235-8362
J101	JACK, Binding post, insulated	0938-3000	24655	0938-3000	
J102	JACK, Binding post, insulated	0938-3000	24655	0938-3000	
J103	JACK, Binding post, insulated	0938-3022	24655	0938-3022	
J104	JACK, Phone	4260-1030	82389	#111	
PL501	PLUG, Power	4240-0600	24655	4240-0600	5935-816-0254
P501	PILOT LIGHT, (Mazda #44)	5600-0700	24454	MAZDA 44	6240-057-2887
S101	SWITCH, Wafer	7890-3100	76854	Type H	
S102	SWITCH, Wafer	7890-3110	76854	224675-F1	
S501	SWITCH, Toggle	7910-1300	04009	83053-SA	5930-909-3510
T101	TRANSFORMER, Output	0745-4250	24655	0745-4250	
T501	TRANSFORMER, Power	0745-4240	24655	0745-4250	
Q101	TRANSISTOR, 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q102	TRANSISTOR, 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q103	TRANSISTOR, 2N1304	8210-1304	01295	2N1304	5961-892-0800
Q104	TRANSISTOR, 2N176	8210-1760	04713	2N176	
Q105	TRANSISTOR, 2N1305	8210-1305	96214	2N1305	5961-853-1079
Q106	TRANSISTOR, 2N176	8210-1760	04713	2N176	
Q501	TRANSISTOR, 2N1540	8210-1540	80211	2N1540	
Q502	TRANSISTOR, 2N3903	8210-1132	93916	2N3903	

*For Type 1311-A.
**For Type 1311-AU.

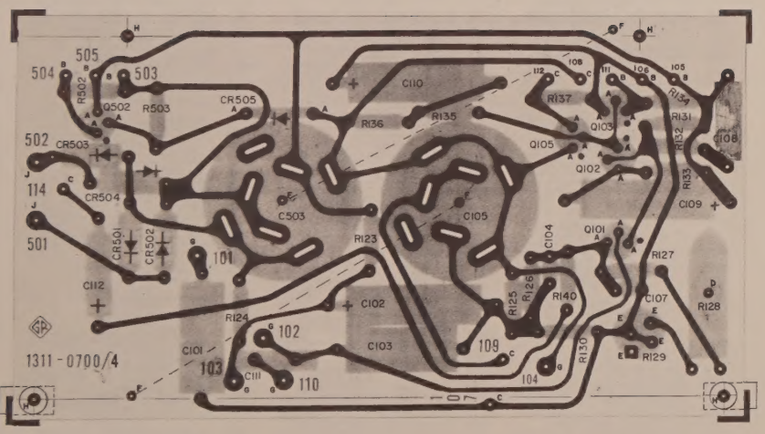


Figure 5-5. Etched circuit board (P/N 1311-2701).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

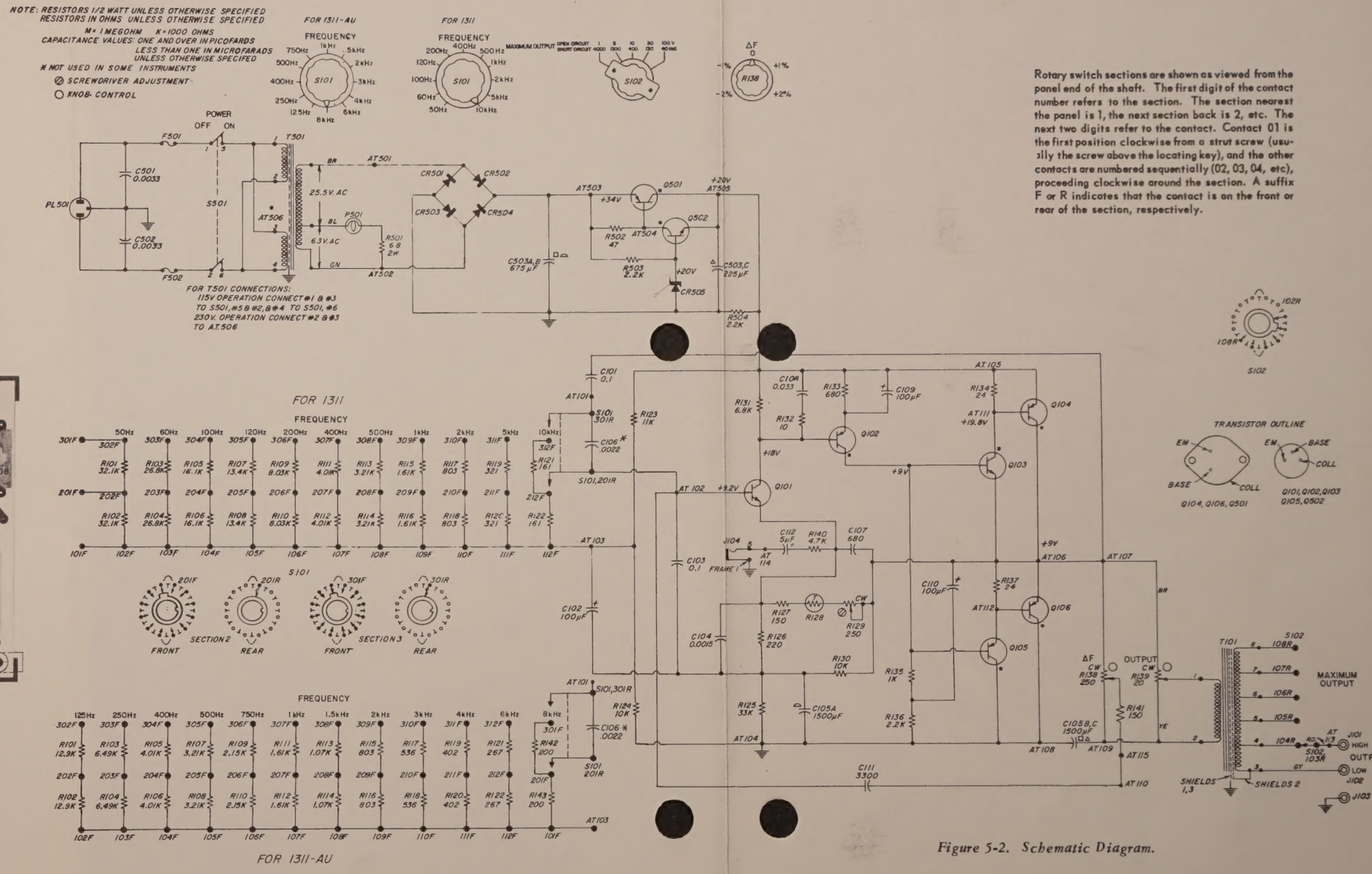


Figure 5-2. Schematic Diagram.

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Claires Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Aris. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
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07829	Bodine Electric Co., Chicago, Ill. 60618
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07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
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09213	General Electric Semiconductor, Buffalo, N. Y.
09408	Star-Tronics Inc., Georgetown, Mass. 01830
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11236	C.P.S. of Berne, Inc., Berne, Ind. 46711
11599	Chandler Evans Corp., W. Hartford, Conn.
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12672	RCA Commercial Receiving Tube and Semi-conductor Div., Woodridge, N.J.
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13327	Solitron Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
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15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
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19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
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24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
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56289	Sprague Electric Co., N. Adams, Mass.
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